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STUDY OF STABILITY PROBLEMS AND HAZARD EVALUATION IN THE MISSOURI PORTION OF THE TRI-STATE MINING AREA

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16. Abstract (Limit 200 words)

A two year investigation has disclosed 469 hazardous sites resulting from past zinc lead mining in the vicinity of Joplin Missouri Aerial photo analysis fieldwork library research and personal interviews were conducted to locate and describe the abandoned mining areas and their associated hazards Open shafts subsidence pits and other mine related dangers exist in areas easily accessible to the public Accidents involving humans and livestock have been reported Some recent damage to buildings and roads can be attributed to the collapse of underground mine workings A few landowners have employed successful methods of safeguarding dangerous sites In addition some surface reclamation has been effected by gradual removal and use of mine and mill waste rock with subsequent leveling and reuse of the land Other than backfilling shafts nothing has been done to stabilize undermined areas A continuing problem is indicated Under present laws most government reclamation funds are designated for coal mined lands A comprehensive program of hazard control and monitoring for the entire study area is warranted

17. Document Analysis a. Descriptors

Mines Shafts Open Pits Subsidence Hazards Tailings Ponds Waste Piles

b. Identifiers/Open-Ended Terms

Tri State District Hazard Assessment Stability Problems

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tailing sludges and mill ponds, but most are now breached The small size and shapes of the individual ponds were difficult sometimes impossible to detail at the required scale The majority of the ponds in the district were of this type Elaborate revetments were constructed in the mining areas to control surface drainage, they were not included in the interpretation Some Kansas piles and ponds shown on the Joplin West and Carl Junction map plates are numbered and correspond to descriptive information recorded in table A-3 (appendix A)

Tabulations

Three tables (appendix A) were prepared to present specific information pertaining to the various numbered sites appearing on the map plates All tabular data pertaining to sites in the Kansas portions of the Joplin West and Carl Junction quadrangles were provided by James R McCauley, principal investigator for the Kansas study area

Tables A-1 and A-2 list descriptive site information for the hazards shown on plates 2A-D Four-part site numbers are used to key tabular data to particular hazards From left to right, each site number gives the following locational information 1) township, 2) range, 3) section, and 4) hazard number within that section, as shown on the map plates Thus, the site number 28-32-16-10 refers to the following location township 28, range 32, section 16, hazard 10 within that section Data pertaining to open shafts are contained in table A-1 Information on subsidences and open pits is recorded in table A-2 Both tables list hazardous sites by quadrangle, beginning with Joplin East and proceeding clockwise through the study area Data for hazards lying in the Kansas portions of the Joplin West and Carl Junction quadrangles are listed at the end of each table

Table A-3 contains descriptive site information for numbered chat piles and tailings ponds on the Kansas portions of plates 3-B and 3-C

LOCATION, TOPOGRAPHY, AND HYDROLOGY

The Missouri study area (fig 1), measuring approximately 625 km^2 (240 mi^2), is included within the following USGS 7½-minute quadrangles Joplin East, Joplin West, Carl Junction, and Webb City, an area comprising a large portion of southwestern Jasper County and a small part of northwestern Newton County In the project area, Interstate 44 is the major highway and Joplin is the largest city

The Missouri portion of the Tri-State Mining District lies on the northwest flank of the Ozark uplift The land surface slopes westward toward Kansas and Oklahoma Elevations vary from 360 m (1200 ft) on the east to 240 m (800 ft) on the west Relief in the area ranges from 24 m (80 ft) on the north to 75 m (250 ft) on the south

The study area lies entirely within the Arkansas River drainage basin (U S G S Hydrologic Unit #11070207) Spring River, which flows generally westward, is the main drainage channel in the area Major tributaries, also flowing west, include Center Creek, Turkey Creek, Short Creek, and Shoal Creek At the height of active mining, circa 1910, in the Duenweg-Webb City-Oronogo field (east half of study area), numerous drainage canals were constructed to divert rain and mine waters away from important production-shaft areas These canals remain intact as wet-weather tributaries of Center Creek

Springs in the project area have been measured to flow as much as 0 6 m^3/sec (20 ft^3/sec), or 9000 gal/min during wet weather (6, p 26) Several open shafts were found to have artesian flows averaging about 0 06 m^3/sec (2 ft^3/sec), or 900 gal/min

Two aquifers exist in the area, a shallow one, in Mississippian limestone, is in the mineralized rock zones, a deep one, in Cambro-Ordovician sandstone and dolomite, is well below the ore-bearing strata (6, p 1)

GEOLOGY, STRATIGRAPHY, AND STRUCTURE

The zinc-lead ore deposits of the Tri-State region are in cherty Mississippian limestones The chert occurs as nodules in limestone, and as interbedded layers From oldest to youngest, the Pierson (Fern Glen), Reeds Spring, Elsey (Grand Falls), Burlington, Keokuk, Warsaw, and Carterville Formations were the host rocks for most of the zinc-lead mineralization Their total thickness in the area exceeds 120 m (400 ft) (9, p 59) Figure 2 is a generalized stratigraphic section for the Joplin District

Small outliers of the Pennsylvanian Cherokee Formation (shales and sandstones) unconformably overlie the Mississippian rocks in some localities Rich ore bodies are associated with these Pennsylvanian sediments where they have filled dissolution structures (sinkholes and collapses) in the Mississippian strata

Throughout the Tri-State District, extensive chemical dissolution of carbonate rock produced horizontal and vertical channels, porous breccia zones of insoluble cherts, and other subsurface cavities (14, p 7) These voids proved excellent repositories for ore precipitation and concentration from mineralized fluids

Structure in the area is limited to gentle folding, the axes generally plunging northwest The regional one-degree dip of the sedimentary formations is also northwestward, away from the Ozark uplift (4, p 411) The Joplin anticline and adjacent Webb City syncline are believed to have influenced the localization of rich trends of mineralization around Joplin and Webb City (11, p 38) Minor faulting and fracturing provided increased zones of rock dissolution and, eventually, channels for ore-bearing fluids

ORE DEPOSITS

The major ore minerals of the Tri-State District are sphalerite (zinc sulfide) and galena (lead sulfide) Marcasite, pyrite (iron sulfide), and chalcopyrite (copper-iron sulfide) are of minor importance Small amounts of greenockite (cadmium sulfide) are also present (14, p 8)

Near-surface oxidation of these sulfides has produced commercially important amounts of smithsonite (zinc carbonate), cerussite (lead carbonate), and hemimorphite (zinc silicate) Gangue minerals include quartz, calcite, and dolomite, the quartz occurring as chert and secondary jasperoid A coloring agent in the jasperoid is a dark, opaque material, bitumen, residual organic matter that appears throughout the mining district, usually in tar-like or hardened masses coating rock surfaces (14, p 8), it is believed to have been instrumental in the chemical reduction of some of the sulfide ores (7, p 3)

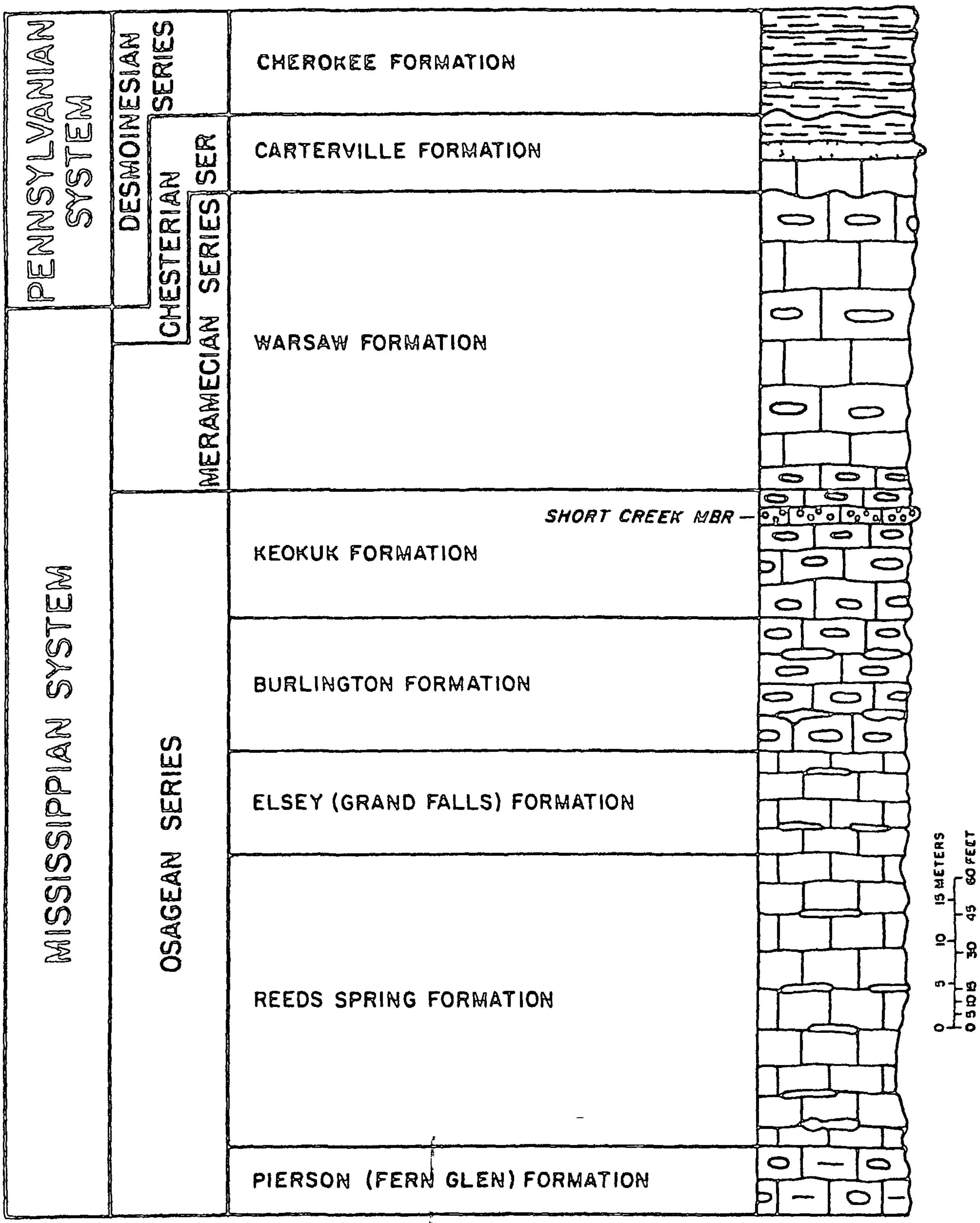

FIGURE 2 — General stratigraphic section Joplin District (modified from 9 pp 59-81)

In Missouri the ore deposits of the Tri-State District have been classified into two main divisions 1) upper-ground, or "broken-ground," deposits and 2) lower-ground, or "sheet-ground," deposits The upper-ground ore zones are associated with incompetent layers of porous chert breccias and loose, unconsolidated masses of clay-like materials, both being remnants of intensive underground solution processes The lower-ground ores are present in more competent beds Mineralization has filled flat, sheet-like voids dissolved out between insoluble chert layers

The ore bodies have several basic shapes, their irregular boundaries determined by the variable host chambers and channels within the dissolved carbonate rock strata (16, pp 59-60) "Runs," long, relatively narrow bodies, tend to occupy the chert breccias and enlarged solution joints of the upper-ground "Circles," arcuate, oval, or circular bodies, develop about shale-filled sink and collapse structures "Sheets," flat, tabular bodies of considerable areal extent, occur in the lower-ground and are intercalated with thin chert beds

The genesis of the Tri-State ore deposits has been studied and debated for over a century Several processes have been proposed to explain the manner in which the ore-bearing solutions were introduced into Mississippian strata in this region (19, p 469) Two theories have been generally accepted as the most satisfactory in explaining these deposits One states that downward-percolating groundwaters, rich in metals, entered all available subsurface dissolution structures and precipitated the ores (5, p 14), the other, that artesian-circulating groundwaters transported the metals through favorable structural weaknesses, ascended into the solution cavities, and precipitated the ores (4, pp 428-429) Further studies will undoubtedly lead to additional theories in attempting to prepare a precise reconstruction of the events responsible for one of the most productive zinc-mining districts in the world

MINING HISTORY, PRODUCTION, AND RESERVES

The discovery of lead ores in the Joplin, Missouri, area during 1848 marked the beginning of mining in the Tri-State District (16, pp 56-57) The associated zinc ores were originally discarded for lack of an efficient, economical technology for recovery of the zinc About 1870, however, the extension of railway lines into southwestern Missouri and the development of new milling and smelting techniques led to the first production of zinc in the area (18, p 127) By 1875, Missouri had become the leading zinc producer in the nation Early mining tracts were small, some leases measuring as little as 60 x 60 m (200 x 200 ft), or about 1 ac (12, pp 19-20) Mining was confined to the upper-ground ore zone, within the first 30 m (100 ft) or so of the surface Due to the broken' nature of this ore zone, drifting operations were limited, therefore, many shafts were sunk at close intervals In fact, Missouri laws required two shafts for each property, usually within 90 m (300 ft) of one another (8, p 150) As a result, thousands of production and prospect shafts were sunk in the district Table 2 shows the numerical distribution of these shafts, as determined for each quadrangle in the study area

As easily accessible mineralized areas were exhausted, shafts were sunk deeper, eventually encountering the lower-ground ore zone, below 30 m (100 ft) "Sheet-ground" ore bodies, ranging in thickness from 2-4 m (7-14 ft), were mined by the room-and-pillar method (3, p 9) From 1902-1907, Harry Kimball of the American Zinc, Lead, and Smelting Company developed mechanized volume-mining methods that allowed these low-grade, but very extensive, "sheet-ground" areas to become profitable before World War I

(12, pp 21-27) High prices for zinc and lead concentrates during the war led to a mining boom, lasting until 1917, in the Joplin and Webb City fields of Missouri A severe collapse of metal prices followed the conclusion of World War I and caused a rapid decline in mining from which the Missouri Tri-State has never recovered Operations were shifted to Oklahoma and Kansas, where extensive deposits had been discovered and large-scale projects were already underway

By 1920, most major mines in Missouri had closed, and the Picher Field of Oklahoma had become the leading producer of zinc in the United States, continuing that prominence through 1946 Several districts in Kansas had also attained high production totals During World War II, increased metal prices and government subsidies permitted operators of some Missouri "sheet-ground" mines to rework low-grade ore deposits at a small profit (4, p 403) The last significant production in Missouri was in 1957, but intermittent output continued into the late 1960's (16, p 58) A summary of Missouri's production is given in table 4

As indicated by table 5, considerable ore reserves remain within the Missouri portion of the Tri-State District Approximately 87 percent of the Missouri ore reserves were under water at the end of 1947 (13, pp 17-18) Most of these flooded deposits are in the Duenweg-Webb City-Oronogo "sheet-ground" field, the largest single area of remaining ore reserves in the Tri-State District

MINE AND MILL WASTE UTILIZATION

Before 1900, in the Missouri portion of the Tri-State District, state laws and local mining methods dictated that existing small tracts and leases be used by the mining companies (8, pp 148-150), who could, in turn, sublease them or portions of them to individual miners Many concentrating mills and plants were necessary for individual mining companies to calculate their royalties The size of each mill varied with the size of the mine or mines being served, and their associated wastes and disposal areas varied accordingly

Waste products (tailings) consist of varying sizes of angular chert fragments chats (1 cm, or 3/8 in, to 35 mesh), sands (35 mesh to 65 mesh), and slimes (65 mesh to 200 mesh) (14, p 13) A large accumulation of graded tailings is shown in figure 3 Boulders (20 cm, or 8 in, and larger) consist of chert and limestone with associated minerals and gangue Figure 4 illustrates a large boulder pile Usually the boulders and chats are mixed and stacked near the mill In many cases, these piles are directly over underground workings, increasing the roof load and the chances of subsidence In figure 5, the tops of "sunken" waste piles are visible in the central portion of the subsidence pit The slimes are concentrated in settling ponds controlled by earthen dikes

Remilling of tailings resulted in the relocation of many chat piles Chats have been processed for use as railroad ballast, road metal, and aggregates in asphalt paving and portland cement concrete Sands and smaller sizes have been used for abrasives, roofing granules, pipe coatings, and filter sands (16, p 168) Boulders have been used for fill material and rip-rap, with some crushing to smaller sizes for use as ballast It has been estimated that 80 percent of the mine wastes have been removed and recycled (14, p 13) The Independent Gravel Company operates two recycling plants in the area, reporting approximately 230 m^3 (300 yd^3), or 400 short tons, per day to produce sand blasting

TABLE 4 — Mine production statistics for Missouri portion of Tri State District 1907 1945[1]

Unit	Material treated		Metal recovered	
	Crude ore	Old tailings	Zinc	Lead
Metric tons	108 026 062	4 016 877	3 157 656	780 215
Short tons	120 028 958	4 463 197	3 508 507	866 905

[1]Short ton data from 10 pp 22 23

TABLE 5 — Ore reserve estimates[1] based on 1½-percent cut-off for Missouri portion of Tri State District December 31 1947[2]

Unit	Crude ore	Recoverable concentrates	
		60-percent zinc	80 percent lead
Metric tons	24 440 400	812 065	57 740
Short tons	27 156 000	902 294	64 156

[1]Based on measured indicated and inferred ore

[2]Short ton data from 13 p 14

FIGURE 3 – Mine waste pile containing mixed chats

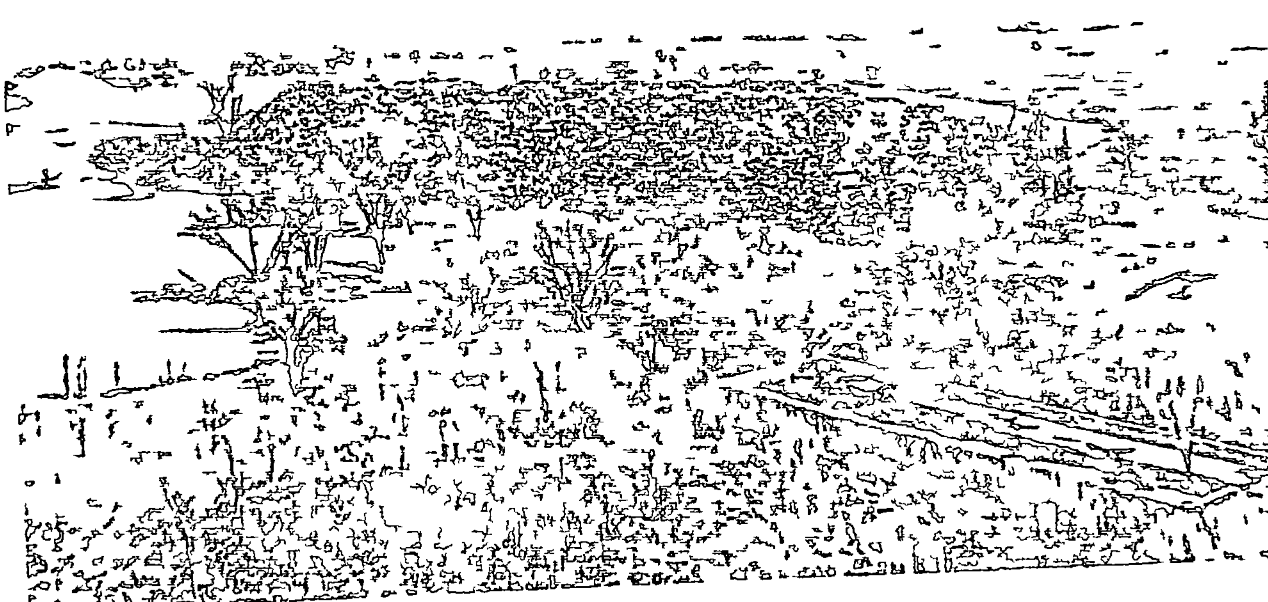

FIGURE 4 – Mine waste pile containing chats and boulders

FIGURE 5 — Mine waste pile subsided below surface

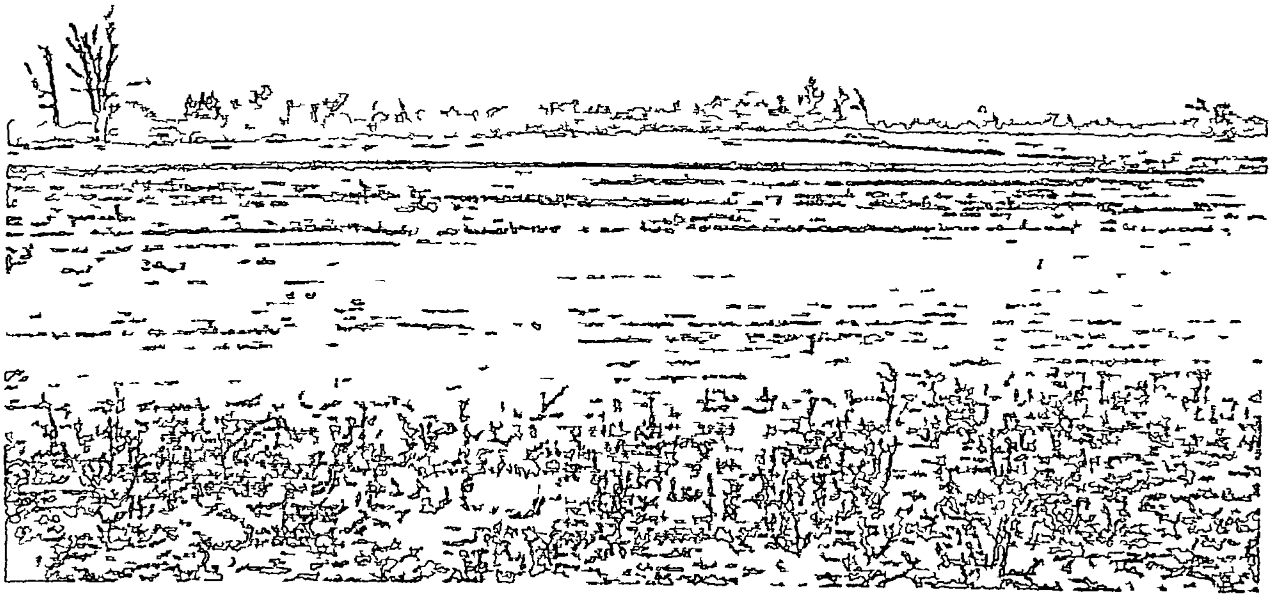

FIGURE 6 — Reclaimed mine area utilizing leveled chats

materials (17, p 25) Several smaller companies also process the mine tailings for commercial use

Estimated reserves of approximately 6,000,000 m^3 (8,000,000 yd^3), or 10,000,000 short tons, in waste products exist in the study area (15, pp 56, 60) As shown in plates 3A-D, very few large piles remain Extensive areas of scattered mounds and thin-layered "chat-flats" exist throughout the study area Some areas have been reclaimed by leveling and incorporating the remaining chats with the soils and overburden Figure 6 shows such an area reclaimed for industrial use Most waste piles and their surrounding areas are barren, except for refuse dumps, and are likely to remain in this unsightly condition Reclamation will be expensive

DESCRIPTIONS OF HAZARDS AND SUGGESTED METHODS OF CONTROL

The tables in this report (appendix A) indicate that many actual and potential safety hazards and environmental problems have resulted from over a century of mining in the project area Open mine shafts, subsided areas having steep, unstable slopes, and open pits containing deep pools of water exist throughout the region Damage to buildings and roads above shaft areas and underground mine workings have been reported Accidents to people and livestock frequenting or wandering into abandoned mining sites in rural areas have also occurred In addition, water-quality problems result from artesian flow of mine waters from open shafts, and rainwater runoff and seepage from tailings piles and settling ponds In the following paragraphs, typical hazards and problems are described and several methods of controlling or eliminating them are suggested

Some 323 open mine shafts have been located and described during the course of this study (table 3) Their surface expressions range from 0 9 m x 0 9 m (3 ft x 3 ft) square holes with vertical sides to 15 m (50 ft)-diameter openings with unstable, funnel-shaped slopes Figures 7, 8, and 9 illustrate typical shaft openings Depths to water level were found to be as much as 36 m (120 ft); however, some shafts were water-filled to the surface or actually having artesian flow (fig 10) Some shafts descend to dry, choked bottoms 4 5 - 18 m (15 - 60 ft) below the surface These dry-bottomed holes result from partial filling with various materials, such as mine waste-rock, junk-metal, forest debris, and assorted household trash The most hazardous sites are open shafts concealed by surrounding trees and/or other vegetation

Effective methods of closing off or, at least, safeguarding these dangerous openings are badly needed Backfilling with available tailings and mine waste-rock would provide closure and aid in reclaiming affected lands Concrete foundations, boulder piles, and chat accumulations in most cases are immediately adjacent to open shafts. These materials could be used as fill It is only necessary that earth-moving machinery have access to the shaft area Although many backfilled shafts observed in the field show slumping and settling of the fill, the danger of long, vertical drop-offs has been effectively removed Figures 11, 12, and 13 depict shafts backfilled with various materials

Another method of closing a dangerous shaft is sealing, or capping, the opening at the surface Such a procedure requires competent rock around the shaft opening and some type of solid base to which a seal can be attached Open shafts with concrete collars or wood cribbings intact at the surface possess suitable bases for several types of temporary seals Metal plates welded together and anchored securely to a base form an effective closure (fig 14) Metal or wooden cross-members have been placed over a base and covered with poured concrete mixes or heavy slabs (fig 15)

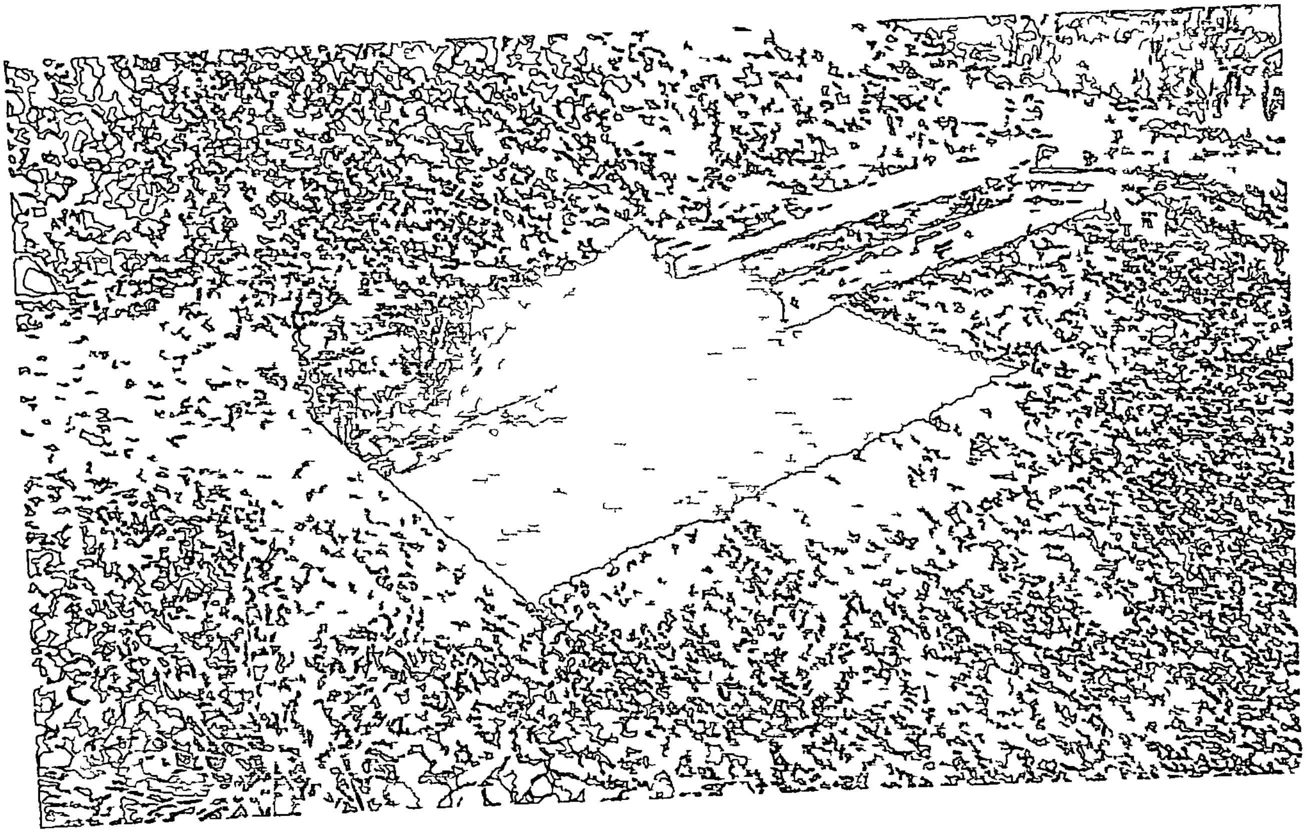

FIGURE 7 – Open shaft with intact concrete collar

FIGURE 8 – Open shaft with funneling sides

FIGURE 9 – Open shaft with collapsed wood cribbing

FIGURE 10 – Artesian shaft issuing mine waters

FIGURE 11 — Closed shaft filled with rubbish

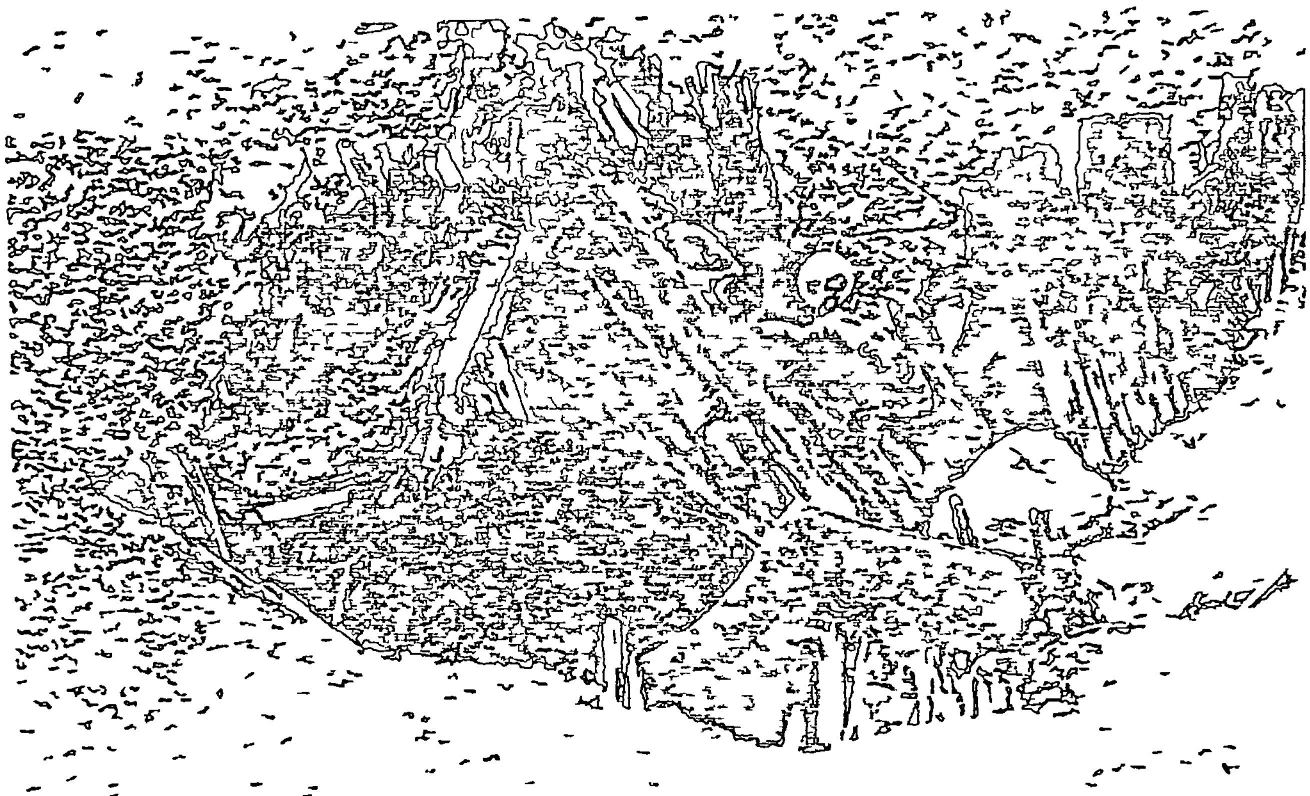

FIGURE 12 – Closed shaft backfilled with chats

FIGURE 13 – Closed shaft backfilled with chats and concrete foundations

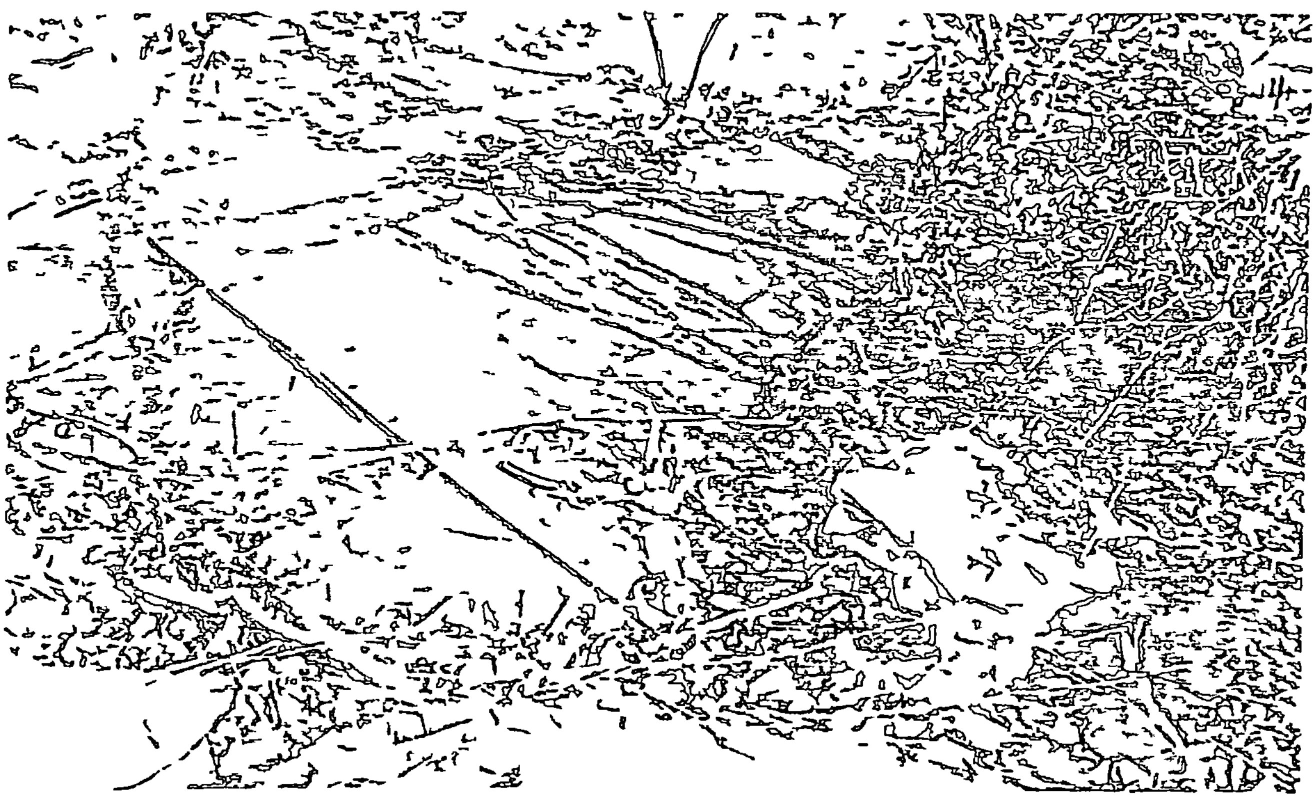

FIGURE 14 — Closed shaft protected with metal plates

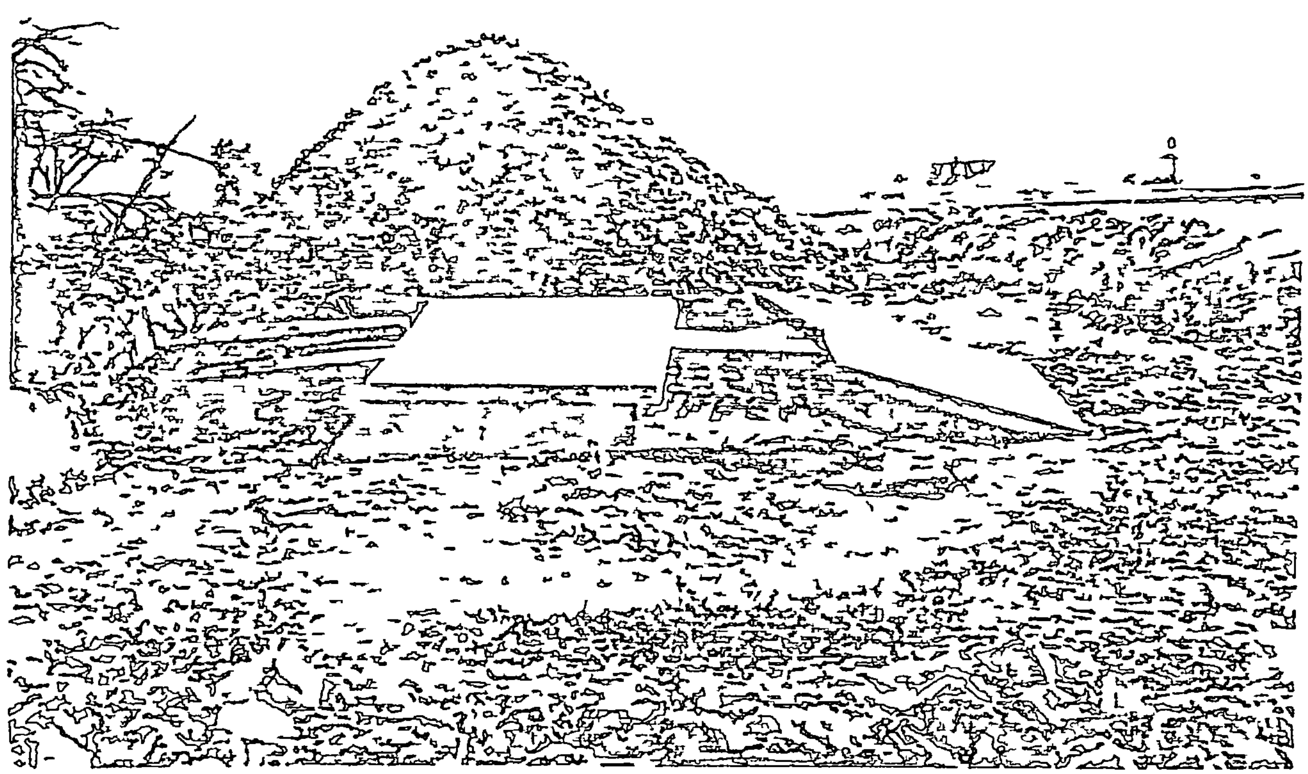

FIGURE 15 — Closed shaft protected with concrete slabs

Some open shafts lead to underground mines having considerable ore reserves. In such cases, suitable procedures would be to affix a temporary cap, as shown in figure 14, or erect sturdy metal fencing around openings and post "danger" signs, a method that would serve to warn but still allow access to the mineral reserves. Figures 16 and 17 show enclosures around open shafts lying above "sheet-ground" reserves in the Duenweg-Webb City-Oronogo field.

In the project area, 124 subsided areas have been inventoried (table 3). They are round, oval, or elongate pits usually containing deep pools of water and having steep, unstable slopes (fig. 18). The pits are 0.02 - 0.4 km^2 (5 - 10 ac) in area. These collapsed areas closely follow the outlines of underground workings, evidence that weak and/or thin roof rock once capped these mines. Subsidence pits are water-filled where they are directly connected to flooded underground mine workings. Dry-bottomed subsidences occur where such connections no longer exist. Subsidence pits have long been popular dump sites for all kinds of refuse (fig. 19), a practice that has only added to the problems of water pollution and unsightly abandoned mined lands.

Because water-filled pits are directly connected to the mines, backfilling the pits and plugging their connections to underground workings seems the only solution, but would require enormous amounts of fill. Unfortunately mine and mill wastes adjacent to subsided areas could hardly begin to provide enough material for such attempts, hence, other economical fill materials would have to be procured.

The steep slopes of dry subsidence pits could be reduced to gentler grades, thus removing the primary danger of near-vertical drop-offs. Backfilling could also be attempted if sufficient fill material were available. In all cases, posting of "danger" signs would provide minimum initial safeguards. The potential for future collapse of these pits into the mine workings with subsequent flooding exists.

In areas where zinc and lead ores were highly concentrated, open-pit mining was employed (3, p. 9), seven such sites have been inventoried (table 3). Large circular holes over 60 m (200 ft) deep and up to 240 m (800 ft) in diameter were carved out by the miners. These large voids are almost completely filled with water today, constituting dangers similar to those of flooded subsidence areas. Because of their immense size and accessibility, local people regularly visit these sites for scuba-diving, swimming, and fishing (fig. 20). Drownings have been reported at the famous Oronogo Circle (fig. 21) since it began to fill with water after 1948 (16, p. 222). People are currently aware of the inherent dangers associated with these abandoned open pits, but continue to enjoy recreational activities at these sites.

Mine-related water-quality problems exist throughout the study area. Many open shafts were found to have wet-weather or perennial artesian flow of mine waters to the surface. Rainwater runoff and seepage from waste piles is also common. The effects of these processes have been examined (1) and some possible solutions proposed (14, 17). Stability problems arise as the downward movement of surface waters accelerates deterioration of ground adjacent to open shafts, thus promoting further collapse. In addition, subsided areas experience increased widening of their perimeters as well as further steepening and undercutting of their slopes. Backfilling or sealing hazardous sites would greatly reduce the damaging effects of such waters. Fenced areas around open shafts should be of sufficient size to prevent fences from being undercut by gradual collapse near the tops of the shafts.

FIGURE 16 – Open shaft and collapsed area safeguarded with metal fencing

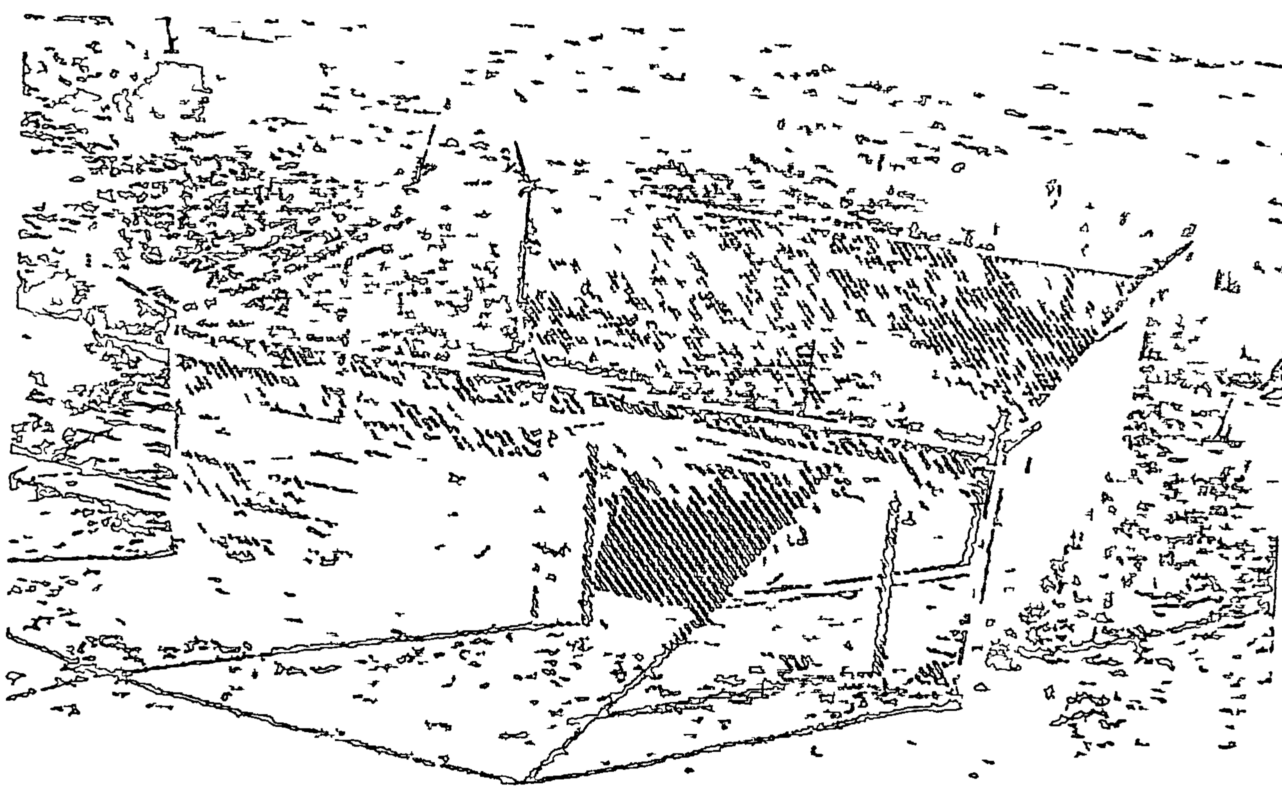

FIGURE 17 – Open shaft safeguarded with metal fencing

FIGURE 18 — Subsidence pit filled with water

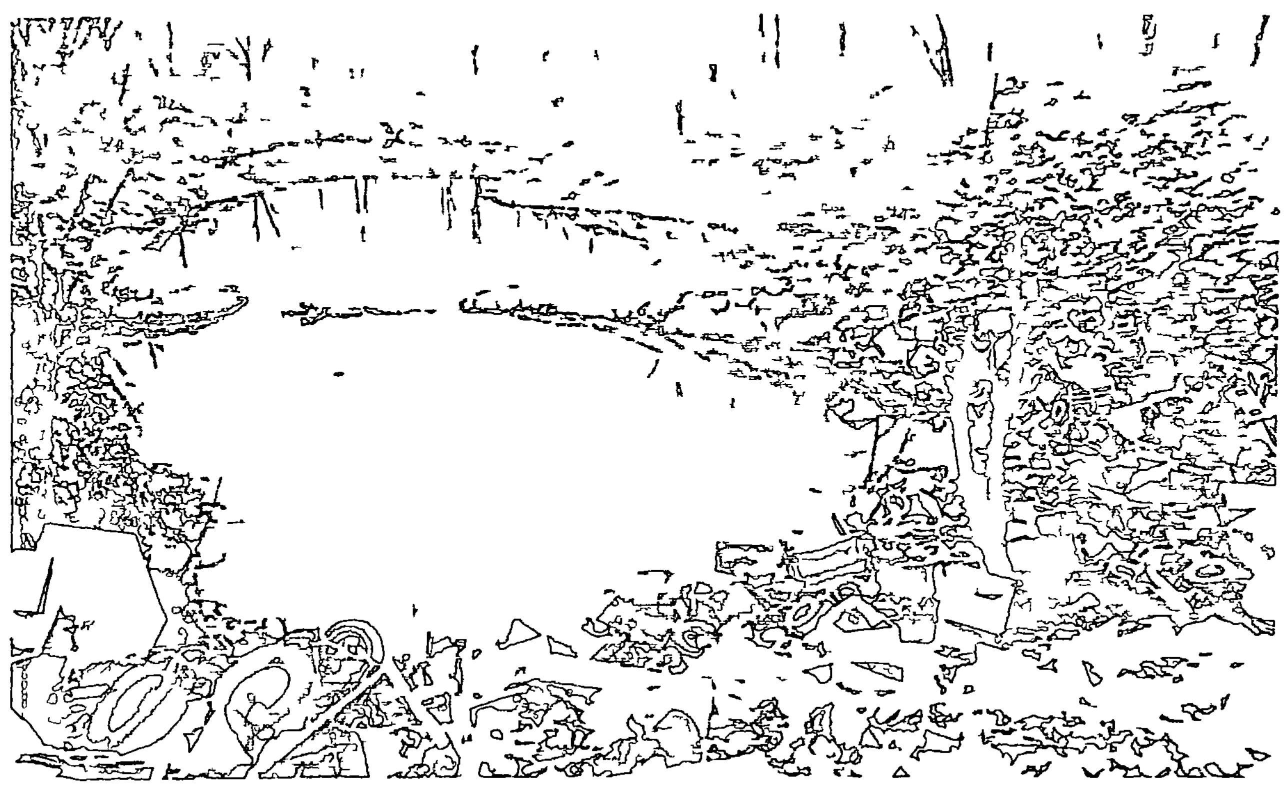

FIGURE 19 — Subsidence pit filled with water and rubbish

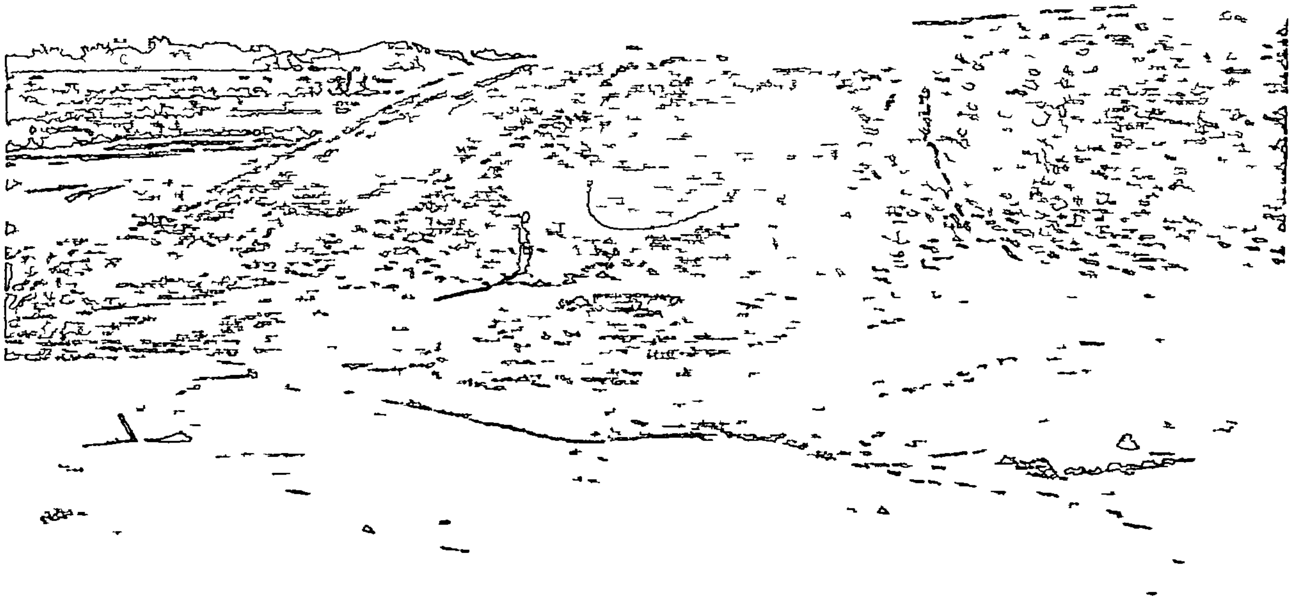

FIGURE 26 – Collapsed area within chat pile

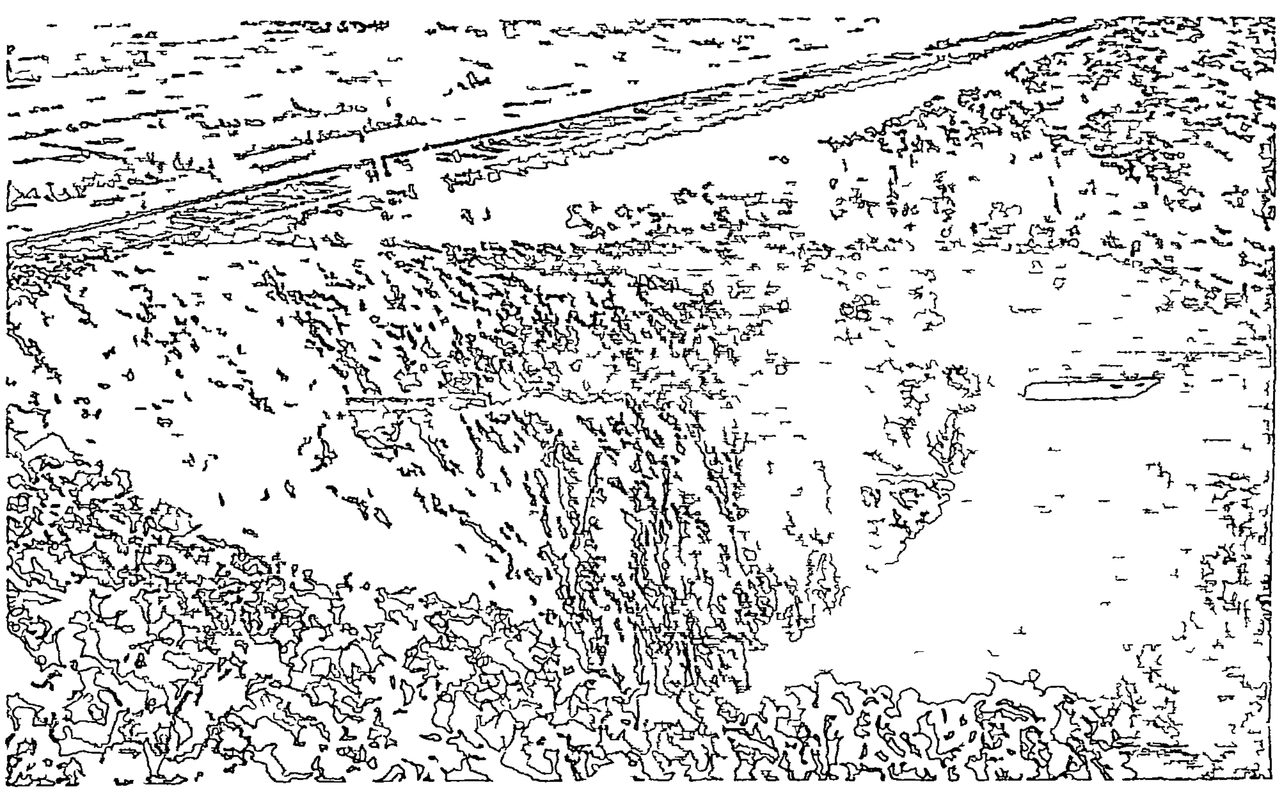

FIGURE 27 – Collapse at top of open shaft encroaching on railroad

Recent collapse is evident at many sites Trash dumps were observed adjacent to those pits and shafts that are easily accessible Both stability and environmental conditions in this area are likely to degrade further

Fourteen hazardous openings, characterized by collapsing beds of incompetent Pennsylvanian rock in their steep, caving sides, are present in a very unstable tract of land (NW¼ SW¼ sec 31, T 29 N , R 32 W), just east of the renowned Oronogo Circle Depths to water level in these holes range from 4 5 - 15 m (15 - 50 ft) Because of their proximity to the town of Oronogo, these sites should be backfilled or fenced to provide some degree of public protection

A total of 196 hazardous sites (141 open shafts and 55 subsidence pits) were found in an area extending 3 2 km (2 mi) northwest-southeast on either side of Webb City and Carterville (secs 6, 7, 8, 17, 18, 20, and 21, T 28 N , R 32 W , secs 1 and 12, T 28 N , R 33 W) The land between these two cities is particularly crowded with dangerous mine openings, there are 87 hazardous sites in an area of approximately 2 km^2 (500 ac) In addition, refuse dumps are abundant, and several shafts with artesian flow are discharging reddish-brown mine waters into Mineral Branch (known locally as "Ben's Branch"), a tributary of Center Creek Only a comprehensive reclamation program will improve such conditions Another 109 hazardous sites were seen outside the two cities The most seriously affected areas are near Center Creek (sec 6, T 28 N , R 32 W) and Prosperity (sec 21, T 28 N , R 32 W), where subsidence has caved in 0 014 - 0 016 km^2 (3 5 - 4 ac) tracts of surface ground (site numbers 28-32-6-16 and 28-32-21-24) Public access to hazardous sites in these regions is largely uncontrolled Fencing mine openings and posting "danger" signs would provide inexpensive, temporary safeguards

A final consideration with respect to future stability problems concerns the potential for reopening of backfilled shafts Funnel-shaped depressions in tailings piles result from gradual settling and subsidence of fill materials into shafts beneath the piles (fig 26) Most backfilled shafts in the study area also show slump features at the surface (figs 11 and 13) This same deterioration process is occurring around tops of open shafts Sloughing of easily eroded soils and incompetent rock layers has caused many open shafts to expand laterally at the surface Figure 27 illustrates a collapsing shaft encroaching on a nearby railway line, thereby posing dangers to personnel and equipment Caving and subsidence at shaft sites, both open and closed, will continue to be a persistent problem

SUMMARY OF LAWS APPLYING TO ABANDONED METAL-MINING AREAS

The following is a compendium of federal and Missouri laws pertaining to abandoned metal mines and lands The federal surface mining laws apply primarily to coal mining, however, sections are included which address the problems of non-coal mining It should be noted that funds will be used for non-coal problems only if public health and safety considerations are endangered This allow the Governor to request that moneys be used from the trust fund established for this purpose The Abandoned Mine Reclamation Fund is administered by the Secretary of the Interior through the Office of Surface Mining All coal reclamation projects have priority to draw on the fund As coal reclamations are completed, the remaining money in the fund could be used for non-coal reclamations Continued research for effective and adequate reclamation of metal-mining areas could greatly enhance the prospects of using the fund as coal reclamations are concluded

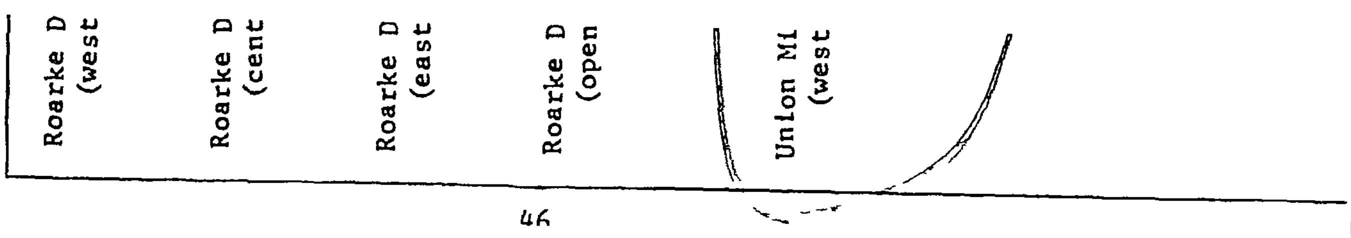

Table A-1 - OPEN MINE SHAFTS - Continued

Name	Site #	Location	Present Condition	Suggested Remedial Action
Center Creek Mining Company Mine (east workings-northeast shaft)	28-32-17-32	SE-SE-SE-NW-SW Sec 17-28N -32W Webb City Quad Jasper Co , Mo	Shaft is open and water-filled to surface, 4' X 4' wood-cribbing is visible below water	Cyclone fencing and posting 'DANGER" signs should provide reasonable safeguards
Center Creek Mining Company Mine (east workings-northwest shaft)	28-32-17-33	SW-SE-SE-NW-SW Sec 17-28N -32W Webb City Quad Jasper Co Mo	Shaft is open and water-filled to surface 3' X 3' wood-cribbing is visible below water	Cyclone fencing and posting "DANGER" signs should provide reasonable safe guards
Ben Franklin Mine (south shaft)	28-32-17-36	SE-SW-NW-SW-SW Sec 17-28N -32W Webb City Quad Jasper Co , Mo	Shaft is open 10' X 10' concrete collar is intact 15' deep to trash fill	Back-fill materials are in the area chain-link fencing and warning signs are also suggested
Ben Franklin Mine (north shaft)	28-32-17-38	E2-NW-NW-SW-SW Sec 17-28N -32W Webb City Quad Jasper Co Mo	Shaft is open, 40' in diameter at surface, caving 20' down to water level 8'-diameter pool Mississippian bedrock exposed in shaft walls	All mining waste (chats boulders concrete) in area can be used for back-filling
Sunset Mine (west workings-south shaft)	28-32-17-39	SE-NW-SE-NW-SW Sec 17-28N -32W Webb City Quad Jasper Co , Mo	Shaft is open within chat pile 3' X 3' wood-cribbed hole is water-filled	Chat/boulder piles in the vicinity could be used for back-filling purposes
Sunset Mine (west workings-east shaft)	28-32-17-40	C-N2-SE-NW-SW Sec 17-28N -32W Webb City Quad Jasper Co , Mo	Shaft is open and producing an artesian flow 20' in diameter at surface, sides are unstable	Back-filling recommended nearby chat/boulder piles can be used for fill material
Sunset Mine (west workings-central shaft)	28-32-17-41	NE-NW-SE-NW-SW Sec 17-28N -32W Webb City Quad Jasper Co Mo	Shaft is open within chat pile 10' in diameter at surface hole is water-filled	All mining waste (chats boulders concrete) in area can be used for back-filling